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TITLE: IMPROVEMENTS IN THE LAMPF LAMB-SHIFT POLARIZED SOURCE

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IMPROVEMENTS IN THE LAMPF LAMB-SHIFT POLARIZED SOURCE*

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ABSTRACT

Modifications which have improved the intensity and reliability of the LAMPF polarized ion source are discussed.

DISCUSSION

Design of the LAMPF Lamb-shift polarized ion source (Figure 1) began in August, 1975. It was initially patterned quite closely after the original source at LASL's Van de Graaff accelerator.[1,2] The primary difference was LAMPF's use of ion pumps rather than diffusion pumps. However, severe argon instability problems arose with the ion pumps and they were replaced with turbomolecular pumps. The source vacuum is now maintained at 2×10^{-6} Torr in the duoplasmatron region and 10^{-7} Torr throughout the rest of the source. This improvement has resulted in approximately 50% higher beam intensity over that previously attained at the 10^{-5} Torr level. The increase is attributed to two factors: 1)higher attainable Accel(duoplasmatron beam extractor) electrode voltages and 2)less collisional de-excitation of the H(2s) beam.[3,4]

Another major step in intensity improvement was taken when the duoplasmatron plasma expansion cup geometry was changed from conical to cylindrical. The two cups are shown in Figure 2. For stable operation, the plasma surface within the expansion cup must remain stationary. Cesium buildup on the cup surface seems to cause the plasma surface to shift around. The conical type cup appears to work satisfactorily when the duoplasmatron is run with a DC arc because plasma heating minimizes the cesium buildup. With a 6% arc duty factor, however, the buildup can become severe. Since the cesium cell is located only a few centimeters from the duoplasmatron, a geometry compatible with the coating had to be installed. The cylindrical cup achieves this compatibility through use of the re-entrant edge located at the cup boundary.[5] This modification provides nearly double the polarized beam available with the conical cup.

Figure 3 illustrates the present Accel/Decel electrode arrangement. The Accel electrode is radially supported by three equally spaced 3.2mmϕ alumina insulators and the decelerating electrode is mounted directly to the end of the cesium cell. This close coupling of the entire system provides a given beam intensity at relatively low cesium cell temperatures. For example, in

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unpolarized operation, 45 μA of 750 keV beam is produced with a 90°C cesium cell temperature. This intensity is presumably due to the increased cesium density in the Accel/Decel region, resulting in greater space charge neutralization than that available with the cesium cell spaced further from the duoplasmatron.

The capability of differentiating between H(2s) atoms and non-polarizable beam components has recently been added. In the region just after the spin filter, the H(2s) beam component can be quenched to the ground state and the resulting Lyman-alpha radiation detected. In this location, one can measure both the relative amounts of H(2s) beam produced in the cesium cell under varying conditions and the absolute efficiency of the spin filter. Being located halfway along the source, the detector system has proved invaluable for troubleshooting source malfunctions. Present plans call for another detector system to be added at the exit of the cesium cell so that comparative measurements may be made of H(2s) intensities at the two locations.

The spin direction of the polarized beam must be reversed periodically to reduce systematic experimental errors, a process generally carried out by reversing the magnetic fields within the source. However, for very precise measurements, this reversal rate is much too slow. To achieve a higher reversal rate, LAMPF employs 180° spin precession of the 500 eV H(2s) beam. The technique requires a low level axial magnetic field between the spin filter and argon cell. A low inductance transverse field coil is placed within this region to precess the H(2s) beam. The transverse field presence or absence provides the two spin directions. Switching times between states is presently limited to 20 μS.

To achieve planar spin precession all external fields must be significantly reduced. This requires extensive magnetic shielding which raises the pumping impedance of the region and leads to a less than desirable vacuum. Studies are presently being carried out to determine if the region can be redesigned to improve the vacuum and also use the same hardware both for rapid spin reversal and for a Sona transition.

One experiment which required rapid spin reversal also necessitated the use of feedback signals from experiment to source to stabilize beam intensity and spin direction. Biased voltage to frequency and frequency to voltage systems were developed to send these millivolt-level bipolar low frequency signals the length of the accelerator and across the fiber optic link into the injector dome. This system has turned out to be very stable and its use has expanded into other areas.

Since the first accelerated beam of 10 pAavg in 1977, the source intensity has risen slowly. Today a balance must be struck between low current beam with high polarization(5nAavg @ 90%) and high current with low polarization(50nAavg @ 60%). The maximum in P^2I occurs at about 20 nAavg and 78% polarization. These currents depend on the accelerator duty factor of course. Peak currents from the ion source have been measured as high as 1200 nA at 60% polarization.

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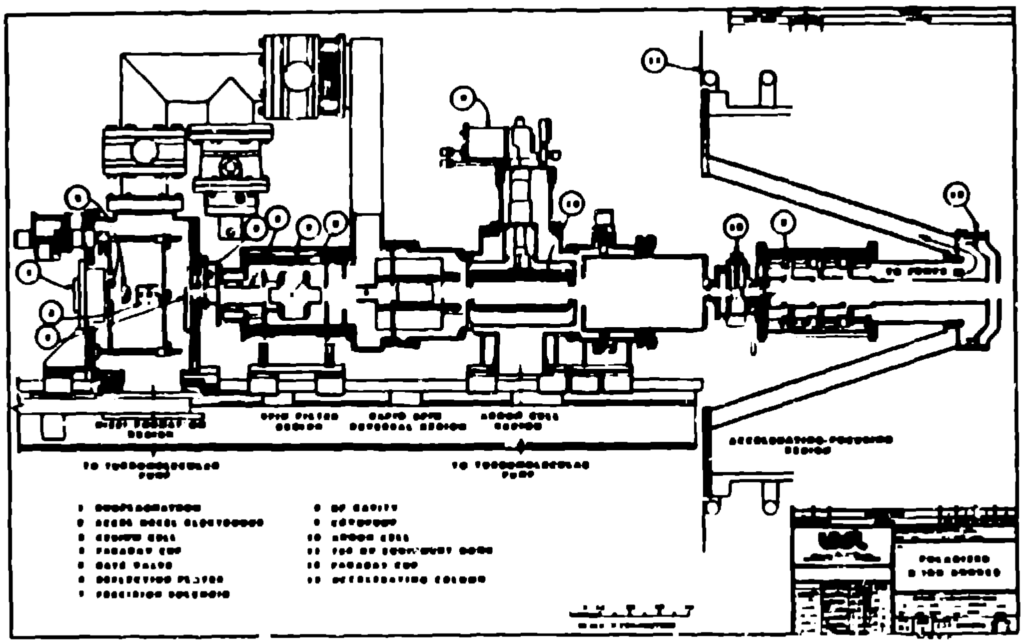

Figure 1. Side view of the LAMPF polarized source

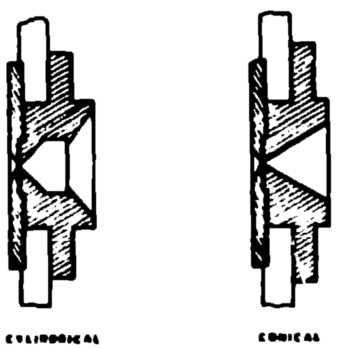

Figure 2. Comparison of the conical and cylindrical duoplasmatron plasma expansion cups.

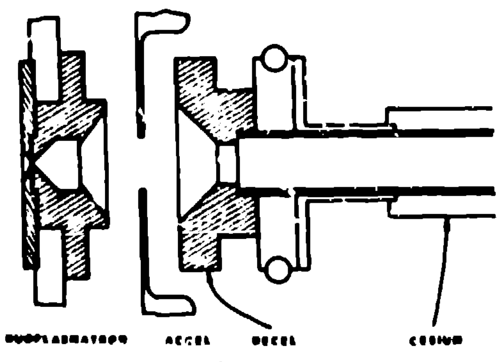

Figure 3. Arrangement of the Accel/Decel electrode region.